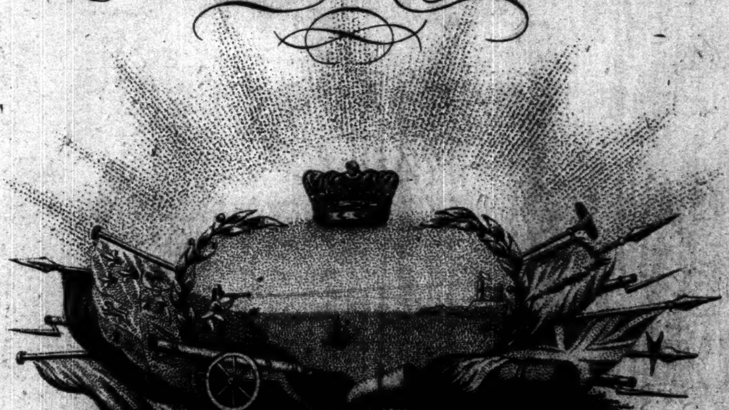
DESCRIPTION and USE of the PATENT Military and Naval Telescope, for Measuring Distances and the Extension of Objects at SIGHT;

By means of a new Micrometrical adjustment.

DEDICATED BY PERMISSION

To His Royal Highness the Duke of York



T.H. Poppleton Pinx. Holmes Fecit.

INVENTED by

C. Rand.

LONDON.

Printed for the Author; and sold with the TELESCOPE. *at Watkins, Optician, N.° 70, S.t James's Street.*

DEDICATION.

TO HIS ROYAL HIGHNESS

THE DUKE OF YORK,

BISHOP OF OSNABURGH,

FIELD MARSHAL, COMMANDER IN CHIEF

OF

HIS MAJESTY's FORCES, &c. &c.

SIR,

WHEN I HAD THE HONOUR OF BEING INTRODUCED TO YOUR ROYAL HIGHNESS, TO EXPLAIN THE PRINCIPLES OF A MILITARY TELESCOPE, WHICH I HAD ORIGINALLY CONSTRUCTED FOR THE PRIVATE USE

OF

OF THE RIGHT HONOURABLE THOMAS PELHAM, FOR ASCERTAINING DISTANCES, AND THE EXTENSION OF OBJECTS AT SIGHT, BY MEANS OF AN ENTIRELY NEW MICROMETRICAL ADJUSTMENT; I WAS HIGHLY FLATTERED BY YOUR ROYAL HIGHNESS'S PROFESSIONAL OBSERVATIONS ON IT, AND GREATLY GRATIFIED THAT IT MET THE APPROBATION OF A PERSONAGE SO EMINENTLY QUALIFIED TO DECIDE ON ITS GENERAL AS WELL AS ITS PARTICULAR MERITS.

THE FIELD OF THE MICROMETER HAVING BEEN SINCE VERY CONSIDERABLY ENLARGED, IS AN IMPROVEMENT WHICH, AS IT ENCREASES THE UTILITY OF THE TELESCOPE FOR THE ARMY, RENDERS IT ALSO OF EQUAL IMPORTANCE TO THE NAVY, AND FOR ALL GENERAL PURPOSES, WHERE ASCERTAINING THE DISTANCE OR THE EXTENSION OF OBJECTS IS REQUIRED.

PATRONIZED BY YOUR ROYAL HIGHNESS, I HAVE THE HONOUR OF DEDICATING TO YOU THE FOLLOWING PAGES, EXPLANATORY OF THE PRINCIPLES,

AND

AND ILLUSTRATIVE OF THE VARIOUS USES AND ADVANTAGES OF THE MILITARY AND NAVAL TELESCOPE.

I HAVE THE HONOUR TO BE,

SIR,

YOUR ROYAL HIGHNESS'S

MUCH OBLIGED,

MOST OBEDIENT, AND MOST DEVOTED

HUMBLE SERVANT,

CATER RAND.

LEWES, FEB. 1, 1799.

INDEX.

INDEX.

Numerical

ERRATUM.

In the Note, page 8, for "Cap-pieces" read "Tube."

DESCRIP-

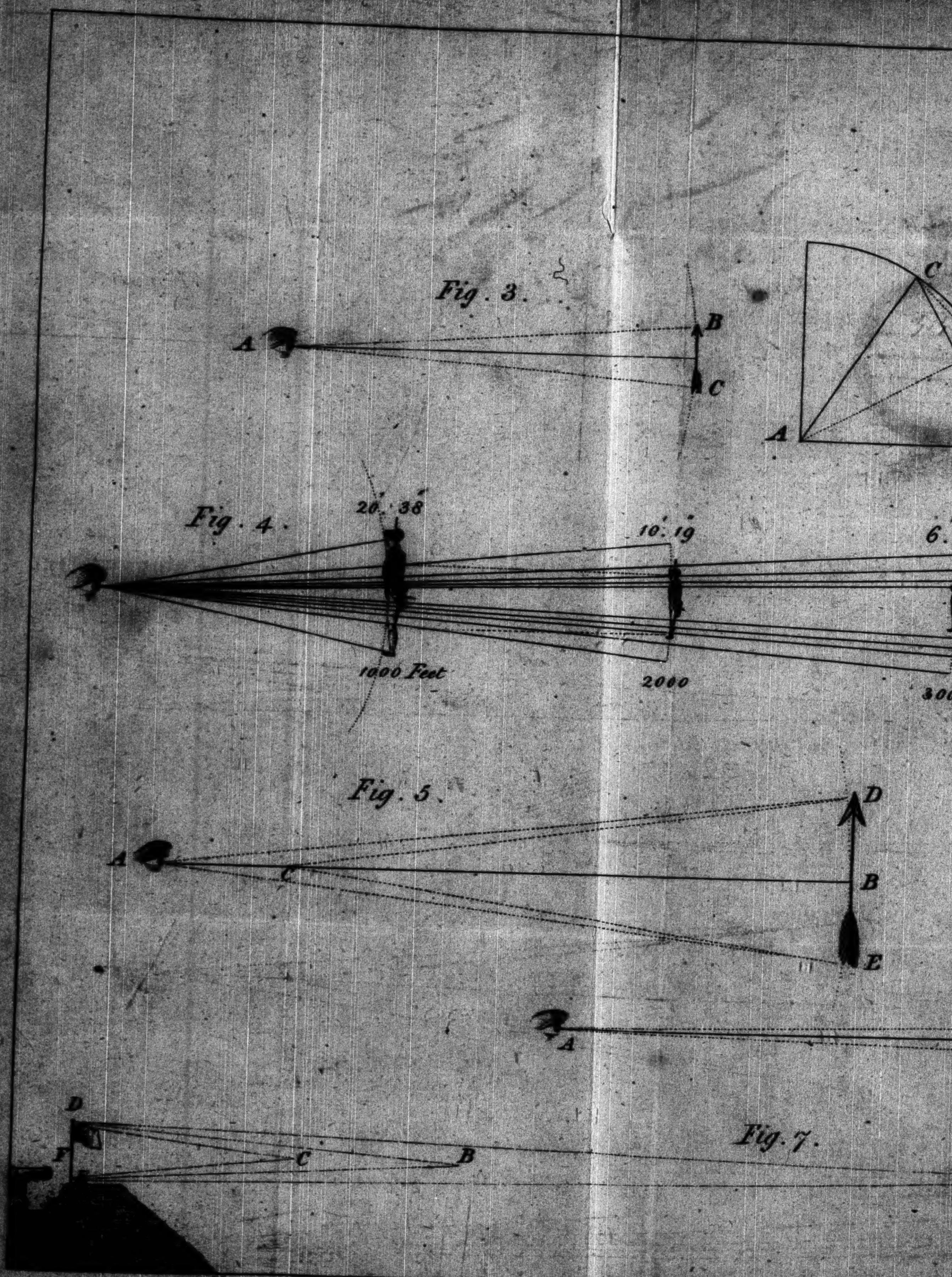


Fig. 3.
A
B
C
Fig. 4.
20′. 38″
10′. 19″
6.
1000 Feet
2000
300
Fig. 5.
A
C
D
B
E
A
Fig. 7.
D
F
C
B

Fig. 2.

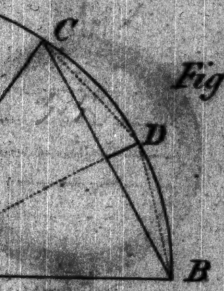
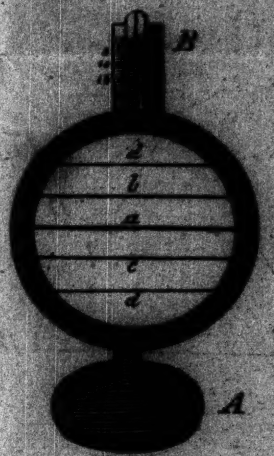


Fig. 1.



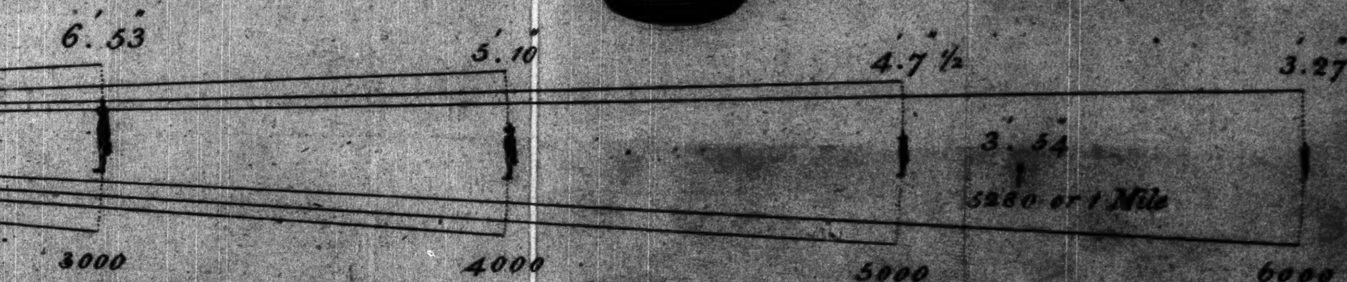


Fig. 6.

DESCRIPTION, &c.

THERE is nothing new in the application of a Micrometer to a Telescope, for measuring small angles or distances. The Patent one, however, about to be described, differs very materially from any thing of the kind ever offered to the public; and will be found far superior to any other in its application to all the various purposes to which it is more peculiarly adapted.

It has long been a *desideratum* to measure the distance of objects at *one* station, instead of *two*, as hitherto practised, from the ends of a base-line; and some ingenious contrivances have been suggested for that purpose; but no

inſtrument has yet been made at all calculated to obtain that end.

The fixed Mother-of-Pearl Micrometer of Mr. CAVALLO's, ſituated in the Focus of the Eye-glaſs, could the objects be defined to that degree of preciſion neceſſary to meaſure the angle ſubtended with accuracy and truth, would, from its ſimplicity and cheapneſs, be of great public benefit.

The Inſtrument deſcribed in Vol. I. of the Repertory of Arts, page 163, invented by Mr. JAMES PEACOCK, of *Finſbury-ſquare*, Architect, for meaſuring diſtances from *one* ſtation only, is certainly ingenious; and the "idea of a Dendrometer, or inſtrument, for meaſuring diſtances by *one* obſervation, by W. PITT, Eſq. of *Pendeford*, near *Wolverhampton*," is ſtill more ingenious; and had he followed up *his* idea by the conſtruction of an inſtrument ſomething ſimilar to the one deſcribed in the

the ſame Work, Vol. II. page 238, it would have ſuperſeded, in a great degree, the neceſſity of the Patent one.

The teleſcopical part of the Patent Inſtrument for meaſuring diſtances, &c. at *one* ſtation, is of the beſt poſſible conſtruction; and the micrometrical peculiarly adapted to anſwer all the purpoſes for which it is deſigned, as will be amply ſet forth in the following pages, and illuſtrated by a great variety of examples, in real practice. To give an hiſtorical account of the Micrometer, its invention, uſe, various conſtruction, and application, as well to the Microſcope as the Teleſcope, would too far exceed the limits of a mere deſcriptive pamphlet, explanatory of its principles adapted to the Teleſcope only. To perſons deſirous of further information, the Encyclopædia Britannica; Hutton's Mathematical and Philoſophical Dictionary; the Philoſophical Tranſactions, &c. &c. may be conſulted.

When the Micrometer is adapted to the Microſcope, it is to meaſure lineal extenſions, as the length, &c. of the ſmalleſt inſects, the diameter of a hair, &c. &c. but when adapted to the Teleſcope, it is for the more immediate purpoſe of meaſuring ſmall angles, and thence the diſtance of objects, as will be fully explained, to the entire ſatisfaction of every perſon who may be in poſſeſſion of the Patent Teleſcopical Micrometer.

Although the Patent Teleſcope may be made of different ſizes or lengths, ſome with ſlides, others in one length, as thoſe uſually made for the Navy, yet the *principle* of each, and of every ſhape and ſize, will be the ſame; they will *all* anſwer the ſame preciſe purpoſe, and meaſure the ſeveral diſtances or extenſion of objects, with one and the ſame degree of accuracy. It may be proper to obſerve, that the Patent Teleſcope, beſides the advantages ariſing from its peculiar conſtruction for the

 more

more immediate uſe of the Army and Navy; in meaſuring diſtances, &c. at ſight, by one or more obſervations, has all the properties in common with other Teleſcopes, for viewing objects on the horizon, or for celeſtial obſervations of any kind; in meaſuring the apparent diameters of the ſun, moon, and planets; the cuſps of the moon in eclipſes; the diſtance of the ſatellites from their reſpective planets; the diſtance between a planet, ſtar, and the moon, approaching to, or receding from, occultations, &c. It may alſo be uſed as a Microſcope, as will be hereafter deſcribed.

The Micrometer adapted to the Patent Teleſcope has both a *fixed*, as well as a *moveable*, value; and herein its principles differ from any other;—and it has a field ſufficiently large to anſwer every purpoſe to which it can be applied; or to which it is intended to be applied by the artilleriſt or nautical obſerver, in the menſuration of diſtances, &c. or to the curious in *their* obſervations;

vations; either in viewing objects, as a common Telescope, before mentioned, or minute objects, as a Microscope.

The principles then of the micrometrical part of the Patent Telescope, and wherein it differs from *all* others, are these: as above observed, it has a *fixed*, as well as a *moveable*, value, to ascertain the angle subtended by any object to be measured by it, as the diameter of the sun, the distance between two stars, the height of a man, the *angle* subtended by any cape or head-land, viewed at sea; a fort, church, or mill; or any remote object, *whereby* the respective distances, &c. may be found from the place or places of observation; and this without any previous knowledge of trigonometry, and the tedious method by logarithmic calculations; but, as it were, by inspection only, by merely entering the table of horizontal distances, at page 24, with the subtending angle of the object, and, corresponding thereto, the respective distance

may

may be found without any further trouble or difficulty, than computing the several distances, and bringing them into such measure of yards, feet, inches, or other measure, as may be required, or the extension of the objects happen to be given in.

EXPLANATION OF THE SEVERAL FIGURES IN THE PLATE.

Fig. 1. A. B. C. shews, in plano, the Micrometer of the Telescope; A. the Nut, or Screw-head, that regulates the mechanism of the parts, and gives motion to the several parallel hairs, or wires, *a. b. c.*—*a.* being a double hair, or wire, that, on the motion of the parts behind C. the protuberant part of the Eye-tube of the Telescope, by means of the Nut, or Screw-head, at A. opens parallel to the extent of *b.* and *c.* which, at the same time, and regulated

lated by the ſame motion of the Nut, move parallel and to the dotted lines, *d. d.* whoſe reſpective diſtances, or parallel openings, forming an angle, the eye being the focus, are accurately meaſured by the Scale at B. to which a Vernier, or Nonius, is adapted, that meaſures the ſubtending angle of any object, within its field, to ſeconds of a degree.

The relative ſituation of the parallel hairs, or wires, *b. c.* are to give the Inſtrument a larger field; and, as their value at reſt, or in motion towards the dotted lines, *d. d.* when an angle ſubtends larger than the field of the double line *a.* is given, the ſubtending angle of any object, within the *whole* field of the Inſtrument, may be eaſily obtained, by only adding the known value of *b. c.* at a fixed value from *a.* to the value of the double lines *a.* opened to their full extent, read off the ſcale B.*

The

* The fixed value will be engraved in the Cap-pieces of every Teleſcope.

The Micrometer, with all its adjuſtments, is placed in its proper ſituation in the Eye-piece of the Teleſcope; and for reading off the fine diviſions of the ſcale B. with its Vernier or Nonius, a ſmall Lens is placed before it; but which could not, without confuſion, be ſhewn in the figure.

The ſcale of the Micrometer is divided into hundredths of an inch; and, when the Vernier points to the firſt diviſion, the hairs or wires will all ſtand exactly parallel to each other, as in the figure; the double hairs or wires at *a.* appearing as one.

Suppoſe two lines to be drawn from the oppoſite edges of the ſun's diſc, from thoſe of the moon, or any other object, to the eye of the obſerver; viewing either of the above objects through the Teleſcope, the angle formed by ſuch lines, converging to the eye, is meaſured by the Scale of the Patent Micrometrical Teleſcope to minutes and ſeconds of a degree.

To meaſure the angle ſubtended by the ſun, or its apparent diameter, (*the apparent diameter of the ſun varies in the courſe of the year about one minute of a degree, appearing under the largeſt angle in the month of January, and the ſmalleſt in the month of July,*) apply the Teleſcope, with the dark glaſs-ſlide before the eye, to the ſun, and by means of the Nut or Screw-head A. open the moveable parallel hairs or wires *a.* till the upper and lower edges of the ſun's diſc are neatly defined between the center hairs or wires of the Inſtrument; then will the Index on the Scale, by means of the Vernier or Nonius, point out the minutes and ſeconds of a degree that the ſun's diſc ſubtends at that time.

For example:—On the firſt of July, wanting to know the apparent diameter of the ſun, by applying the Teleſcope, with the dark glaſs on, as before directed, to the ſun, the parallel hairs or wires, to ſubtend the angle of the diameter or whole diſc, have moved

the

the Index on the Scale over fifteen divisions; and the Vernier or Nonius stands at about 78 hundredths, which, as will be presently shewn, equals 31′ 34″ nearly. The Nautical Almanack, for the same day, gives the sun's semi-diameter 15′ 46″.9, or 31′ 33″.8, for its whole diameter; varying but two tenths of a second from the instrumental measure by the Patent Telescope.

Again:—If, on the first of January, the Telescope be applied to the sun, as before directed, it will be found that the angle subtended by the sun's disc, or whole diameter, will pass sixteen divisions on the scale, and that the Vernier or Nonius will stand at about 33 hundredths, which will be found equal to 32′ 39″ nearly, the apparent diameter or angle the sun subtends on *that* day: The Nautical Almanack, for same day, gives 16′ 19″.4 for its semi-diameter, or 32′ 38″.8 for its whole diameter, varying, as before, about two tenths

 of

of a ſecond, or 12‴ of a degree of a great circle.

To explain in what manner fifteen diviſions on the Scale, and the Vernier or Nonius ſtanding at about 78 hundredths, is equal to 31′ 34″, and in this way to find the value of any ſubtending angle, within the field of the Inſtrument, which, for all the purpoſes intended, whether for the uſe of the army, the navy, or for common teleſcopical obſervations, is ſufficiently extenſive, this is *The Rule*:—Let the Micrometer diviſions paſſed over by the Index, and the parts pointed out by the Vernier or Nonius, be always DOUBLED; the reaſon of this is, the parallel hairs or wires move through *twice* the ſpace that the Index on the Scale does: hence the neceſſity of *doubling* the diviſions on the Scale, to meaſure the apparent angle ſubtended by any object, as the diameter of the ſun or moon, the diſtance between the moon and a planet, or ſtar, preceding an occultation;

cultation; the ſubtending angle of a diſtant cape or head-land; a ſhip at ſea; a fort or garriſon; mill, church, or other object; the cavalry or infantry of a ſtationary, approaching, or receding army, &c. &c. The diviſions on the Scale, *doubled*, as above directed, meaſure the ſubtending angle in parts of a great circle. For inſtance,—the Index, as before-mentioned, when the Teleſcope was applied to find the apparent diameter of the ſun on the 1ſt of July, ſtood at *fifteen* diviſions on the Scale, and the Vernier or Nonius at about 78 hundredths, which being *doubled* gives 30′ 156 of the hundredths, or 31′ 34″; for every Vernier or Nonius tenth equals 6″ of a degree of a great circle; conſequently 156 hundredths, the *double* of 78 hundredths, pointed out by the Vernier or Nonius, is equal to 1′ 34″; which, added to the *doubled* diviſions, *fifteen*, pointed out by the Index, makes the apparent diameter of the ſun for that day, as before ſhewn, 31′ 34″ nearly; the angle ſubtended by the ſun's diſc.

Again,

Again:—Viewing a caſtle at a diſtance, to meaſure its ſubtending angle—it appears the index has paſſed the fourth diviſion on the Scale, and that the Vernier or Nonius ſtands at 20 hundredths; *doubling* 20 hundredths makes 40, which, at 6″ for every 10 hundredths, equals 24″; this added to the *double* of the whole diviſions 4, makes the angle ſubtended by the caſtle 8′ 24″ of a degree of a great circle.

One example more will be ſufficient to explain the uſe of the Scale, the Vernier or Nonius diviſions, and the manner of reading off the angle.—Applying the Teleſcope to a centinel on a diſtant garriſon, it appears that he ſubtends an angle of 4′ 12″: for the Index ſtands a little below the *ſecond* diviſion on the Scale, which *doubled* gives 4′, and the Vernier or Nonius at the ſame time cuts *one* tenth, or ten hundredths, equal to 6″, which alſo *doubled* give 12″, and added to the two diviſions *doubled*, makes 4′ 12″, the apparent angle ſubtended by the centinel at the garriſon. To find the

angle

angle ſubtended in all caſes, *double* the diviſions on the Scale, pointed out by the *Index*, as well as the *Vernier or Nonius*; the whole diviſions will be equal to *degrees*, and *minutes* of a great circle, if above 60; and every tenth of the Vernier or Nonius will be equal to 6″ of a degree of a great circle, as above obſerved.

NOTE. As the Patent Teleſcopical Micrometer may fall into the hands of perſons unaccuſtomed to, or totally unacquainted with, the uſe of the Vernier or Nonius, it may be proper to give the following conciſe explanation of it.

The Vernier's, or Nonius Scale, is a ſmall graduated ſcale, which [redacted] the ſide of the Micrometer Scale B. Fig. 1. and the value of its diviſions are read off thus: If the Index, as in the laſt example, ſtands between the ſecond and the third diviſion on the Micrometer, or left-hand Scale, the diviſion of the Vernier or Nonius Scale, that is ſeen to coincide with a diviſion of the Micrometer, or left-hand Scale, points out its *value* in tenths or centeſms; every tenth of which equals 6″ of a degree: ſo that the *two* whole diviſions on the larger Scale, and the *one* tenth on the Vernier or Nonius, equal when *doubled*, four minutes and two tenths, or twenty centeſms, or 4′ 12″, and ſo of any other value, always allowing 6″ for every tenth on the Vernier or Nonius Scale. A little practice will ſoon familiariſe the reading off the diviſions on both Scales to a very great nicety.

It

It is hoped the *above* explanation of the *value* of the Micrometer's Scale is ſufficiently elucidated to enable any perſon to find the angle ſubtended by an object, with which he is to enter the following Table of Horizontal Diſtances, to find out the true diſtance of the object, and, from the place of obſervation, as will be ſhewn by a ſufficient variety of examples, to prove the great uſefulneſs, and ſuperior advantage, of the Patent Inſtrument above any thing of the kind for Military and Naval purpoſes, where the aſcertaining diſtances, and the ſize or ~~extenſion~~ of objects is promptly required.

Having ſufficiently explained the mechanical effects of the Micrometer, and ſhewn how to find the *value* of an angle for aſcertaining the diſtances and extenſion of objects, by means of the Table of Horizontal Diſtances; for the ſatisfaction of thoſe who may wiſh to know on what principles the Table is made, Fig. 2. is introduced.

It

It is not intended to enter into any abſtruſe mathematical calculation, ſerving rather to *puzzle* and *confound*, than to convince thoſe for whoſe uſe this ſhort deſcriptive pamphlet is written. Every thing, therefore, will be explained in the moſt ſimple and familiar manner; ſo that perſons, knowing little more of the ſcience of numbers than that *two* and *two* make *four*, may uſe the Patent Inſtrument with as much addreſs as the ableſt Mathematician, by following the mere mechanical rules and directions given; nevertheleſs, to go fully into the explanation and conſtruction of the Table, ſome calculation is neceſſary, and may be expected by thoſe ſomewhat familiar in theſe things.

Fig. 2: is the quadrant of a circle, the angle C. A. B. is iſſoſeles, ſubtending the arch line C. D. B. of the quadrant 57° 17′ 42″, which meaſures the length of the arch line, C. D. B. exactly equal to radius A. B. There are ſeveral

 ways

ways of proving this; one or two simple examples will be fully sufficient in the present instance.

The radius of a circle being 1. the semi-circumference is 3.14159, &c. this number, divided by the degrees in a semi-circle, 180, gives, .01745329, for the length of *one* degree, the radius being *unity*.

To find the length of the arch line C. D. B. multiply continually the radius, the number of degrees in the given arch, and the above number, .01745329 the product will give the length of the arch line.—

Or,

Multiply the chord of *half* the segment, C. D. or D. B. by 8, and from the product subtract the chord of the *whole* segment, C. B. the remainder, divided by 3, the quotient will be the length of the arch line C. D. B. nearly.

Let

Let the radius A. B. equal 71; the chord of the *whole* ſegment C. B. equal 67; the chord of *half* the ſegment 35:—$71 \times 57^{\circ}.295 \times .01745329 = 71$, the length of the arch line C. D. B. *i. e.* 71, the radius, multiplied into $57^{\circ}\ 17'\ 42''$, or $57^{\circ}.295$—($.295$ being the decimal of $17'\ 42''$) and this product into $.01745329$, the decimal length of one degree; the radius being *unity*, gives 71 as above, the length of the arch line equal to radius; and by this method the arch line is found, let the given radius be what it may:—

Or,

The chord of *half* the ſegment C. D. or D. B. = 35, multiplied by 8, and the *whole* ſegment C. B. = 67 ſubſtracted from the product, the remainder, divided by 3, gives alſo the arch line C. D. B. equal to radius 71 given;—and ſo of any other proportion.

$$\begin{array}{r} 35 \\ 8 \\ \hline 280 \\ 67 \\ \hline 3\,)\,213 \\ \hline \end{array}$$

Arch line C. D. B. equal 71 as before.

Hence the Table for computing the Horizontal diſtances of objects, calculated to ſeconds of a degree.

Hence alſo, the reaſon why the Tabular number, correſponding to the angle ſubtended by any object, becomes the *multiplier* to find the diſtance, when the extenſion is known; or the *diviſor* to find the extenſion, when the diſtance is known; or to be uſed, as circumſtances occur, when *neither* diſtance nor extenſion is known, but *one* or *both* required.

The angle ſubtended to make the arch line equal to the radius, is, as above, 57° 17′ 42″, or 3437′ 42″—but in the Table, 3438 is made uſe of, as the neareſt *whole* number, the difference being immaterial;—where decimals are uſed, they are to be underſtood to be thoſe the neareſt to .25 .50 or 75 hundredths.

To find out the neareſt numbers correſponding to a meaſured angle, ſuppoſe, for inſtance,

15′

15′ 25″—ſeek 15′ in the *left* hand column of the Table, and under 20″, in the Horizontal line, ſtands 224, and under 30″ ſtands 222, theſe ſums being added together give 446, the *half* of which is 223, the mean between 20″ and 30″, or the angle of 15′ 25″: and in this way the intermediate number of ſeconds may be found, to any proportion required, even to a ſingle ſecond.

Thus having deſcribed the mathematical as well as the mechanical principles of the Patent Teleſcope, at leaſt as far as it is neceſſary, to its application in practice,—it remains to ſhew the great variety of purpoſes to which it may be applied, not only as a military or naval inſtrument, as heretofore mentioned, but as an equally amuſing, and more generally uſeful Teleſcope than any other, for all the civil purpoſes of ſociety.

Thoſe Teleſcopes conſtructed for *general* uſe are of the ſliding portable ſort, made as plain

and

and ſimple as poſſible, to avoid expence; they may be made, however, in any way required, either for the *pocket*, or fixed on a *ſtand*, as occaſionally wanted. The common portable ſliding ſort are, upon the whole, beſt adapted to military uſes; thoſe in one length for naval; and thoſe mounted on a ſtand for the obſervatory or ſummer-houſe.

In the following Problems and Examples brevity of deſcription, with clearneſs of information, will be ſtudied; and the ſeveral explanatory figures being as ſimple as lines could form them, no technical phraſeology will be uſed, further than what is abſolutely neceſſary to illuſtrate and give full value and effect to each; ſo that every perſon may fully comprehend their uſefulneſs when practically applied.

To perſons, indeed, uſed to trigonometrical calculations, with the help of logarithmic tables, every thing may appear ſimple; the

Table

Table of Horizontal Diſtances will, however, be found uſeful, and ſave much labour and trouble to them; but to thoſe unacquainted with the rules of trigonometry and the uſes of logarithmic tables, the Table of Horizontal Diſtances becomes *abſolutely* neceſſary; and, as hath been before obſerved, may, with a little practice, be uſed with as much addreſs, and truth, by thoſe unacquainted with the mathematics or its principles, as by the deepeſt read in that *noble ſcience*.

TABLE

TABLE

FOR

COMPUTING THE HORIZONTAL DISTANCE, &c. OF OBJECTS,

FROM THE PLACE OF OBSERVATION.

	0″	10″	20″	30″	40″	50″
0	0	20625	10312	6876	5156	4126
1	3438	2946	2579	2292	2063	1875
2	1719	1586	1478	1379	1298	1213
3	1146	1085	1031	982	938	897
4	859	825	793	764	737	711
5	685	665	645	626	607	589
6	573	559	543	529	516	503
7	491	479	469	458	448	439
8	430	421	412	404	397	388
9	382	375	368	362	355	349
10	344	338	333	328	322	317
11	312	308	303	299	295	291
12	286	283	279	275	271	268
13	264	61	258	255	252	248
14	245	243	240	237	235	232
15	229	227	224	222	220	217
16	215	213	210	208	206	204
17	202	200	198	196	195	193
18	191	189	188	186	184	183
19	181	179	178	176	175	173
20	172	170	169	167	166	165
21	164	162	160.6	159.5	158.4	157
22	15[illegible]	155	154	153	152	150
23	149.5	148.5	147.4	146	145	144
24	143	142	141	140.4	139.4	138.5
25	137.5	137	136	135	134	133
26	132	131.4	130.6	130	129	128
27	127	126	125.6	125	124	123.5
28	123	122	121	120.6	120	119
29	118.5	118	117.4	117	116	115
30	114.6	114	113	113	112	111.5

	0″	10″	20″	30″	40″	50″
31′	111	110.4	110	109	108.6	108
32	107.4	106.7	106	106	105	105
33	104	103.6	103	102.6	102	101.6
34	101	100.6	100	99.6	99	99
35	98	97.6	97	97	96	96
36	95.5	95	94.5	94	94	93.3
37	93	92.5	92	92	91.3	91
38	90.5	90	90.3	89.3	89	88.5
39	88	87.6	87	87	86.5	86
40	86	85.6	85	85	84.4	84
41	84	83.4	83	83	82.4	82
42	82	81.4	81	81	80.5	80
43	80	79.6	79.3	79	78.7	78.4
44	78	78	77.6	77.3	77	76.7
45	76.4	76	75.7	75.5	75	75
46	75			73.6		
47	73			72.3		
48	71.6			71		
49	70			69.4		
50	69			68		
51	67.4			66.7		
52	66			65.5		
53	65			64		
54	64			63		
55	62.5			62		
56	61.4			61		
57	60.3			59.7		
58	59.3			58.7		
59	58.3			57.8		
60	57.3			56.8		

To prove the truth and accuracy of the power of the Patent Telescopical Micrometer for measuring distances, &c. from one or more observations, a measured distance or base-line of 2000 yards, on a dead level, and an object of known extension, was made use of; and for greater distances, several of the stations of the late Trigonometrical Survey, by Major-General Roy, &c. which had been proved, were used. Several very accurate observations were also made at sea, coasting in the English and Irish Channels.

PROB. I.

To find the *distance* of an object from the place of observation, its *size* being known—

Example I.—The object B. C. Fig. 3. being known, to determine its distance from the place of the observer at A.

By applying the Telescope to the object B. C. which suppose to be a six-inch ruler or scale, fixed

fixed on a poſt, or ſtuck againſt a wall, by means of a wafer, let the Nut of the Micrometer-ſcrew be turned till the object be well defined, *i. e.* till the upper and lower edges of the ruler or ſcale exactly coincide with the internal ſides of the central parallel hairs or wires; then will the Index point out the angle ſubtended by the ruler or ſcale; which, being found equal to 15 diviſions, on the Micrometer Scale of the Teleſcope, this *doubled* gives 30′, or half a degree of a great circle. With the ſubtended angle of the object, 30′, enter the Table of Horizontal Diſtances, where, in the firſt column of figures, on the left hand, and exactly oppoſite to 30′, ſtands 114.6 in the next column on the right, the tabular number for 30′, which ſhews how many times the diſtance of the object is greater than its ſize; if, therefore, this number 114.6 be multiplied into the ſize of the object, *viz.* the ſix-inch ruler or ſcale, the product will give the diſtance, in ſuch meaſure as the ſize of the object is expreſſed in. The ſize or extenſion of the preſent

ſent object being given in inches, *viz.* 6. theſe multiplied into the tabular number, before ſought, 114.6 gives 687.6 inches, or 57 feet 3½ inches, for the diſtance of the object (*the ruler or ſcale in this inſtance*) from the place of obſervation, or rather from the *eye* of the obſerver. The *converſe* of this will give the ſize or extenſion of the object; for, if the *diſtance*, in the above Example, brought into inches, 687.6, be divided by the tabular number, correſponding to the ſubtended angle of the object 30′=114.6, the quotient will be 6, the known ſize of the object.

Example 2.—Suppoſe the ſpire of a church be known to meaſure 50 feet in height, clear of the battlements; and that, viewed through the Teleſcope, it be found to ſubtend an angle of 4′½ or 4.5 tenths diviſions of the Micrometer Scale, equal to 9′; take out the tabular number for 9′, as directed above, which is found to be 382, this number multiplied into the known altitude of the ſpire, 50 feet, gives

19,100

19,100 feet, or a little more than three miles and a half from the place of the obſerver.

EXAMPLE 3.—Laying off an enemy's battery, at ſea, the height of whoſe flag-ſtaff had been previouſly aſcertained to be 27 feet required its diſtance from the ſhip; the angle ſubtended by the flag-ſtaff, being found by the foregoing rules, to be 26′ 30″—ſeek 26′ 30″ in the Table of Horizontal Diſtances, which will be found 130; this number multiplied by 27, the height of the flag-ſtaff gives 3510 feet, or 1170 yards, the diſtance between the ſhip and the battery.—Experience has taught the moſt able and beſt informed artilleriſt, that nothing in the practice of gunnery is more difficult than to judge *truly* of diſtances by eye, as it is called; and the more eſpecially where objects are viewed acroſs a deep ravin or valley: but with the Patent Teleſcope the diſtance of an object may be almoſt inſtantaneouſly found, if its height be known, even to a foot. The artilleriſt may

may be perfectly master of his gun, know its point blank, and greatest range, according to its charge; but without knowing truly the *distance* of the object to be fired at; the garrison to be stormed; or fort to be silenced; much ammunition may be injudiciously and fruitlessly expended; and this did sometimes happen during the several campaigns upon the Continent, in the present contest:—one instance occurred where several most experienced gunners were found to be several hundred yards out in judging of a distance by eye; varying, according to their respective judgments, from 100 to 500 yards, in a distance of something less than a mile, or 1760 yards: in consequence of which much powder and ball were wasted without the least annoyance to the enemy.

There are situations where it is not practicable to measure the distance of an object from the ends of a base-line, by the rules of Trigonometry. How valuable then must such an instrument

ſtrument be, as the one deſcribed, that will *always* give the diſtance by *one* obſervation if the extenſion of the object be known; as the height of a man, or the mean height of two, three, or four men, &c. &c. or by *two* obſervations, ſuppoſing the object inacceſſible and unknown.

Suppoſe it be required to know the diſtance of an army, appearing in ſight, on a plain; a fort, or garriſon; or ſhip at ſea; where it is next to impoſſible but objects enough of men, &c. will preſent themſelves for aſcertaining the diſtance at *one* ſtation: but ſhould it happen otherwiſe, the ſubtending angle of any, and the *ſame* object, at *two* ſtations, as will be preſently ſhewn, will give the diſtance.

Viewing an enemy's camp on the oppoſite ſide of a river, its diſtance is required to ſee how far it is practicable to *annoy* it from certain ſituations; in this caſe, taking the angles

angles ſubtended by any particular tent, that preſents itſelf, in approaching the camp, at known diſtances from two obſervations, by a ſimple rule to be given, the true point blank diſtance may be eaſily found.—So that, by taking the ſubtending angle of a flag ſtaff, &c. on a fortreſs; or the whole ſubtending angle of a ſhip at ſea; or the angles ſubtended by its maſts or yards, or ports, as circumſtances may offer, the reſpective diſtances may be found; even ſuppoſing *all* the ſoldiers in the garriſon or fortreſs, and *all* the ſeamen, to be out of ſight; which, as before obſerved, is next to an impoſſibility to happen.—Hence the great uſe of the Patent Teleſcope, in a *military* point of view.

Example 4.—Aſſuming the height of a man, merely for examples ſake, (a ſoldier, for inſtance, under arms,) at 6 feet. Figure 4 in the Plate will ſhew the different angles he will ſubtend, at the ſeveral diſtant ſtations, of one, two,

two, three, and ſo on to ſix thouſand feet, or two thouſand yards. The intermediate, and farther diſtances, are found in the uſual way; by entering the Table of Horizontal Diſtances, with the ſubtending angle of the known height of the man, or the mean height of two, three, or four men, which is found by dividing the ſum of their angles by the number of men, *viz.* let the angles, ſubtended by three different men, be 6′ 36″; 6′ 66″; 6′ 57″; their ſum amounts to 20′ 39″, which divided by 3, the number of men, will give 6′ 53″, the mean height; and this angle ſought in the Table of Horizontal Diſtances, and worked as before taught, will give 3000 feet, correſponding to the angle, and diſtance of the third ſoldier, in Fig. 4, from the place of obſervation.—The converſe of this, as in the firſt example, will prove true, and give the height of the ſoldier, the diſtance being known; for if 3000, the diſtance in feet, be divided by the neareſt tabular number to 6′ 53″, the mean

mean angle ſubtended, which will be 500, it will give 6 feet, the height aſſumed.

Again:—What will the height of a man be who is found to ſubtend an angle of 3′ 54″, at the known diſtance of a mile, or 5280 feet. Take out the number from the Table correſponding to 3′ 54″, which will be found to be 880; the diſtance 5280, divided by this number, gives, as before, 6 feet, the height of the man. Suppoſe the angle ſubtended to have been 3′ 50″, inſtead of 3′ 54″, at the ſame diſtance of 5280 feet, or 1 mile, the height of the man would, in this caſe, have been 5 feet 10¼ inches; for the diviſor would have been 897, (*vide* Table) inſtead of 880.—In this way the diſtance is always found, from the known height; and, *vice verſa*, the height from the diſtance.

To prove the laſt Example. The angle C. A. B. Fig. 2. whoſe arch line C. D. B. is equal

equal to radius A. B. brought into ſeconds, and multiplied by the given height of the man, 6 feet, and this product, divided by the ſubtended angle 3′ 54″, rejecting fractions or thirds, will meaſure the diſtance 5280 feet, and all intermediate and greater diſtances may be proved by the ſame method;—rejecting remainders, beyond ſeconds of a degree, of the ſubtending angle, as of no conſequence in *military* practice, as it will not amount to 6 inches in a hundred yards,—if greater nicety be required, as in Trigonometrical, &c. Surveys, the ſubtending angles of the object muſt be read off, and calculated to thirds, &c. of a degree; and the truth will then come out to mathematical preciſion.

The angles ſubtended by the ſoldiers, at every thouſand feet, in Fig. 4. of the Plate, were thoſe *actually proved* by the original Teleſcope, from which every other will be proved for public uſe, and the ſeveral diſtances were

 aſcer-

aſcertained to a foot. This *figure* alſo ſhews the exact proportion and comparative height of the men at the reſpective diſtances from the place of obſervation, and may be of great uſe to painters, as well as to military men.—In many fine landſcapes, &c. where the figures of men and women have been introduced, either ſingly or in groupes, by painters of the firſt eminence, they have been moſt extravagantly in error in this reſpect, a due attention not having been paid to what is called *keeping*, or repreſenting objects under their proper angles, or as they appear to the eye; and this want of *keeping*, or repreſenting objects under very *different* angles from what they *really* do appear in nature, is very remarkable in one of the famous CARTONS OF RAPHAEL, repreſenting the miraculous draught of fiſhes; and in the hiſtorical picture of Chriſt's transfiguration on the mount: the former makes the men appear of *full* ſize, and repreſents the boat ſo *ſmall*, that, as obſerved by Mr. *Ferguſon*, in his

Treatiſe

Treatiſe on Perſpective, "any *one* of the men "ſeems ſufficient to *ſink* the boat." The latter makes CHRIST and his *diſciples*, on the *top* of the mount, nearly as large as thoſe at the *foot*, and the *mother* of the *boy* brought to be cured, though on her knees, nearly half the height of the mount; in which caſe, a ſpectator, at a little diſtance, could as well diſtinguiſh the *features* of thoſe on the top of the mount as of thoſe on the ground; a thing utterly impoſſible, had the *keeping*, or *true* angle that each ſubtended, been attended to.—View Fig. 4. again,—the angles ſubtended by the ſoldiers diminiſh in *true* mathematical proportion, and the features of the men appear leſs and leſs viſible as they recede from the *eye* of the obſerver: this is *true* keeping.—Hence the Patent Teleſcope's uſefulneſs to landſcape and and other painters, to find the *true* diminiſhing angle of all ſorts of objects, preſenting themſelves to their view; particularly the more ſtriking ones of diſtant hills, caſtles, churches,

mills,

mills, groves of trees, &c. &c. as well as single figures, or groupes, of men, women, &c.

It would be uſeleſs to give more Examples to prove the truth and accuracy with which diſtances and extenſion of objects may be taken with the Patent Teleſcope; but having mentioned its uſefulneſs to landſcape painters, &c. to find the diminiſhing angles of diſtant hills, caſtles, churches, &c. it may be proper to ſay, that the diminiſhing angles of objects, and their diſtances, have been proved from a great variety of ſtations, and found to correſpond very nearly to the truth of thoſe mentioned in Major General ROY's Report of the Trigonometrical Survey. The places of obſervation, where other objects did not preſent themſelves, for *trial* of the Patent Teleſcope, had *flag-ſtaves* erected on them, where the diſtances did not exceed five or ſix miles. The places *obſerved from* were, Ditchling Beacon, Suſſex; Chantonbury, Suſſex; Leith-Hill, Surry; Riddleſ-

down,

down, Surry; Sevendroog-Caſtle, Kent; Hampſtead;—Tower of Frant Church; Crouborough Beacon; Signal Houſe at Beachy; Jevington Mill; and the place of Lewes Flag-Staff, in the county of Suſſex.—The objects of known dimenſions, to aſcertain the reſpective diſtances were, the old Tower on Leith Hill; Horſham Church Spire; the Ball, &c. on St. Paul's Church, London; the Spire of Crouborough Chapel; Jevington Mill; Newberry's Tower, on Heathfield Down; Beachy Signal Houſe; Seaford Signal Houſe; Lewes Caſtle; Flag Staff on Mount Caburn; ditto on Mount Harry, near Lewes; ditto at Hollingbury Caſtle, near Brighton; &c. &c. Perſons who have any knowledge of the above ſituations, or who will conſult a Map, will allow that *variety* enough of ſtations have been taken; and *that* in almoſt every direction the diſtance of objects have been meaſured, and proved from fifty to ſix thouſand feet, on the *original* baſe-line, near the Lewes Race Ground, and to the extent of upwards

wards of 22 miles, in the manner before described. Hence, again, the uſefulneſs of the Patent Teleſcope, for *extenſive* Trigonometrical Surveys; and, as will ſometime hence be ſhewn, for all common ſurveys, ſuperſeding, in a great degree, the neceſſity of dragging a chain between ſtations to find the diſtances, and the content in acres; which will be done much quicker, and equally accurate, by this inſtrument, when fitted up as it is intended for that particular purpoſe.

Having ſufficiently explained, and ſhewn how to find the *diſtance* of any object, from the place of the obſerver, when the *ſize* of the object is either known, or aſſumed, as illuſtrated by means of the 3 and 4 *Figures* on the Plate; and *vice verſa*, where the *ſize* or *extenſion* of an object is to be meaſured, when its ſubtending *angle* is taken, and the *diſtance* known:—it remains to be ſhewn, and explained, in what way the *diſtance* and *ſize* of an object is to be found

from

from the place or places of obſervation, when NEITHER of them is known.

PROB. II.

To find the *diſtance* and *ſize* of an object, when both are *unknown*.

Here, *two* ſubtending angles of the ſame object muſt be taken, at any convenient diſtances from each other, in a meaſured right line, approaching to, or receding from the object, as it may be moſt convenient, or at the places of any known radii, where the object can be ſeen.—The angles being taken as before taught.

To find the *diſtance*—the rule is, to multiply the larger angle into the *diſtance* between the *two* places of obſervation, and to divide the product by the difference between the *two* angles:—and, to find the *ſize* of the object, as

ſhewn in the 1ſt and 4th Example of Prob. I. divide the diſtance at either place of obſervation, by the Tabular Number, anſwering the neareſt to the ſubtending angles.

EXAMPLE 1.—Let the *diſtance* and *ſize* of the object, D. B. E. (Fig. 5) from either place of obſervation, as at A. or C. be required. To find firſt the *diſtance*, and from thence the *ſize* of the object; apply the Teleſcope to the object, beginning at either ſtation, ſuppoſe at A, and note the angle ſubtended; which let be 17′; pace, or meaſure, with a chain or ſtaff, when great accuracy is required, any diſtance from A. to C, in a right line with the object, which ſuppoſe 45 feet; at C. apply the Teleſcope again, and ſuppoſe the angle to be ſubtended by the object, from this ſtation, to be 20′:—by the *rule*, multiply the larger angle, 20′, into the meaſured diſtance between the places of obſervation at A. and C.—viz. 45 feet, and the product is 900 feet; this divided by

by the difference of the angles taken at A. and C. 17′ and 20′, which is 3′, gives the diſtance of the object from the fartheſt ſtation, at A, 300 feet; conſequently, from the neareſt ſtation C. 255 feet. The diſtance of the object D. B. E. from both places of obſervation, being found, viz. from A. 300 feet to B. and from C. 255 feet to B, from theſe *data* to find the *height* or *ſize* of the object :---ſeek the Tabular number neareſt to the angle ſubtended by the object at A. 17′,—which will be found 202 ---the fartheſt diſtance 300 feet, divided by this Tabular number 202 gives 1 . 485; or if the diſtance be brought into inches, and divided as above, the anſwer will be 18 inches, nearly for the ſize or height of the object. Again: Seek the Tabular number neareſt to the angle ſubtended by the object from the ſtation at C. viz. 20′, againſt which ſtand, 172; the leſs diſtance, from C. to the object, 255 feet, brought into inches, and divided by the above Tabular number 172, will alſo give 18 inches

 nearly

nearly, for *ſize* or *height* of the object D. B. E. required.

The truth of the above rule is deduced from well known *data*.*

To prove this Trigonometrically at the fartheſt ſtation A. the diſtance being 300 feet from the object: Say,

As rad.	90°.	—	10.00000
Is to *t*.	.17′.	—	7.69417
So is *y*. 300 feet, or 3600 inches			3.55630
To *x*. = 18 inches nearly			1.25047

Again,

* If T. denote the tangent of the larger, and t. that of the ſmaller angle, d the diſtance, between the *two* places of obſervation at A. and C; y the unknown diſtance of the object, from the fartheſt ſtation at A; $y-d$ the diſtance of the object from the neareſt ſtation, at C; r the radius, and x the unknown ſize of the object; then, in ſmall angles, the tangents being as the angles; by the rules of Trigonometry, as $r : t :: y : x$ and $r : T :: y-d : x$; hence $rx = ty$, and $rx = Ty - Td$; therefore $ty = Ty - Td$, and $Ty - ty = Td$, which divided by $T-t$ gives $y = \frac{Td}{T-t}$: therefore the diſtance y, is equal to the product of the larger angle, multiplied into the diſtance between the *two* ſtations, and then divided by the difference of the two angles.

Again, at the nearest station C. the distance being 255 feet from the object: Say,

As rad.	90°.	—	10,00000
Is to T.	20′	—	7.76476
So is *y*—*d*. 255 feet, or 3060 inches			3.48572
To *x*.=18 inches as before.			1.25048

Example 2.—Suppose the same object D. B. E. to be viewed under very different angles and distances, from the last example, its *size* or *height* must come out by the rule the same as before.—Let the *distance* be found as in the preceding Example. Applying the Telescope at station C. the angle subtended by the object is 5′ 30″ (i. e. *the Index stands between the second and third division on the left hand, or Micrometer Scale; and the Vernier or Nonius appears to coincide with a little more than the 7-tenths, or 75 Centesms, which being doubled*, agreeable to former directions, gives 4′ 150 Centesms---but one*

* This *doubling* the divisions, to find at all times the value of the angle on the scale, will not be repeated.

one hundred Centesms being equal to one minute, i. e. 6" *to every* 10 *Centesms*, 150 *Centesms equal* 1' 30" *which added to the* 4' *the double of the two divisions, makes out the subtending angle of the object, as above*, 5' 30") The meaſured or known diſtance between C. the neareſt, and A. the fartheſt ſtation or place of obſervation, let be 780 feet; let the angle of the object at A. be then taken, and found to be 3', then, by the foregoing rule, if the diſtance between the ſtation A. and C. be multiplied into the larger angle of the object taken at C. 5' 30". or which will amount to the ſame thing uſing Decimal Figures, viz. 5.5 and the product be divided by the difference between 5' 30", and 3', which is 2' 30. or as before 2.5 uſing decimals inſtead of ſeconds; it will give the diſtance of the object from the fartheſt ſtation at A. equal to 1719 feet, or as will be uſed for cloſer Logarithmic calculation, 20628 inches; and the *diſtance* between the ſtations A. and C. 780 feet or 9360 inches, being ſubſtracted from the

the quotient, or 20628 inches, leaves the diſtance of the object from the neareſt ſtation, 939 feet or 11268 inches. The logarithmic calculation will be *once* more ſhewn to prove the *ſize* or *height* of the object to be the ſame as before.

To find the *height* of the object D. B. E. from the fartheſt ſtation A.

As rad.	90° —	10.00000
Is to *t*.	— 3′	6.94084
So is *y*.	20628 in.	4.31428
To *x*. = 18 inches, as before		1.25512

To find and prove the *height* at the neareſt ſtation C.

As rad.	90° —	10.00000
Is to T.	— 5′. 30″	7.20408
So is *y*—*d*.	11268 in.	4.05150
To *x*. = 18 inches, as before		1.25548

Example

Note, The diſtances are brought into inches for nicer logarithmic calculation.

EXAMPLE 3.—An army presenting itself on the opposite bank of a river, a soldier is observed standing close to the water's edge;—Required the breadth of the river?—Assuming the height of the soldier with hat and shoes at 6 feet, (but this is of no consequence, because the subtending angles at the two places of observation will always *prove* the height.) He appears to subtend an angle of 6′ 25″, which, by the rule of finding the distance, at a single observation, by taking out the tabular number for 6′ 25″, (in this case the mean of the two nearest numbers, *viz.* 6′ 20″ and 6′ 30″, or 543 and 529, added together, and divided by 2, will give a mean tabular number, 535, equal to the angle of 6′ 25″) which being multiplied as heretofore, by the height of the soldier, will give the distance 3210 feet, or 1070 yards, for the breadth of the river.—To prove both the soldier's height, and the distance or breath of the river—let 900 feet, or 300 yards, be measured or paced back from the verge of the

the river, in a right line as suppose from C. to A. (Fig. 5,) and the subtending angle of the soldier be again taken, and found to be 5′; if 900 feet, or 300 yards, the distance between the two stations, be added to the distance found by the first observation, it will make the distance of the soldier, from the farthest station, 1370 yards, or 4110 feet, which, divided by 6 feet, the soldier's assumed height, the quotient will be 685; the tabular number equal to 5′, the angle subtended by the soldier at the farthest or last station.

The logarithmic proof to find the soldier's height will be, at farthest station, say,

As rad.	90° —	10.00000
Is to *t*.	—. 5′	7.16269
So is *y*.	4110 feet	3.61384
To *x*. = 6 feet, as above		.77653

H At

At nearest station.

As rad.	90.°—	10.00000
Is to T.	— 6.′ 25″	7.27103
So is y—d. 3210 feet		3.50650
To x. = 6 feet, as before		.77753

EXAMPLE 4.—Fig. 6. shews the western tower and part of the ruins of Lewes Castle, *before whose walls was fought the memorable battle between KING HENRY the THIRD and the BARONS on the 14th May*, 1264. There is nothing very materially different in this from the preceding Examples, only that, from the point C. to the Castle is a deep ravin or valley, and that the ground at C. is not favourable to form an accurate base-line to ascertain the distance from thence to the Castle by the rules of trigonometry, in the usual way, which is so readily done, as in the former directions, by the Patent Telescope. The distance, however, between the two places of observation, at A. and

and C. in this Example, is much greater than in any former one, which goes to *prove* that it is of no consequence, in point of distance, from whence the subtending angles of the objects are taken. Let it therefore be required to find the distance from the places of observation, A. and C. to the Castle; and from such *data* the size or height of the window D. B. E. Being too near the tower, at the first place of observation, C. to take into the field of the Micrometer the *whole* subtending angle of it, the window * presented itself as a favourable object to measure its distance; the angle subtended thereby was found to coincide with 7 micrometrical divisions, or 14′; but at station A. the same window subtended only 1 division and a half, or 50 centesms, equal to 3′, the distance between the places of observation be-

 ing

* Any object, as before observed, may be made choice of to find the distance, provided it can be well defined, at both places of observation, when *two* stations are used, *viz.* a window, pane of glass, chimney, course of stones, bricks, tiles, &c. &c.

ing 1200 yards, or 3600 feet, which, multiplied into the greater angle 14′, gives a product of 50400; and this product, divided by the difference of the angles 11′, the quotient will be 4581 feet 9-11, the greater distance from the place of observation at A.—the distance between the two stations at A. and C. subtracted from this number, leaves 982 feet, the distance from the place of observation at C. to the Castle window D. B. E. required. To find the *height* of the window, seek the tabular number coinciding with either angle 3′ or 14′, and let the greater or less distance be divided by it, and the height of the window will come out 4 feet, rejecting remainders, as of no consequence.

The

Greater distance.	Lesser distance.
$\dfrac{4581}{\angle 3' = 1146} = 4$ feet.	$\dfrac{982}{\angle 14' = 245} = 4$ feet.

The *diſtance* and *height* of LEWES CASTLE has been taken from all parts of the ſurrounding country, and at a great variety of diſtances, from 50 feet to 15 miles, merely to prove the truth and accuracy of the inſtrument; but, after the above number of Examples, it would be ſuperfluous to add another, either to ſhew from whence the obſervations were made, or to illuſtrate the method of finding either diſtance or height, the direction for both being ſo ſimple the reader muſt, by this time, be well acquainted with it if the leaſt attention has been paid to the foregoing rules.

ONE Nautical Example will be given, as quite ſufficient for *that* practice.—To find the *diſtance*, and *size* or *height* of an object at SEA, is attended with a little more difficulty, owing to ſeveral cauſes; but the principal are, the irregular and almoſt conſtant *motion* of a SHIP, and the difficulty of meaſuring the *true* diſtance between *two* places of obſervation; but,

but, even here, if due care be taken, every thing may be aſcertained with wonderful accuracy; it is however recommended to make uſe of *three*, inſtead of *two*, obſervations, to guard againſt any material error, where very great accuracy is required; and when the *diſtance* and *ſize*, or *height* of the object, are both required, and neither of them is known. As alſo in finding the diſtance of an iſland, cape, or head-land; either by taking *in* the angle ſubtended by the *whole* iſland, from its ſummit to the horizon, or by ſome prominent leading feature thereon, diſtinctly to be ſeen, and clearly defined, either approaching or receding from it.—It is alſo adviſeable to take the mean of *two* or *three* obſervations, where the *diſtance* is required, from the *ſize* or *height* of a *known* object, which may be done in a few ſeconds if the ſhip is not violently agitated, and if ſhe is ſailing at the rate of *ten* or *twelve* knots an hour, the diſtance of her way, between the times of taking the obſervations,

can

can be but a few yards, which may be *accounted* for. The method of finding the mean angle is shewn in Ex. 4. Prob. 1. Page 32.

Example 5.—Being at SEA, and observing an enemy's fort or battery, let it be required to ascertain its distance from the place of the ship, in three different situations, represented by A. B. C. Fig. 7. The flag-staff being distinctly visible from the farthest place of observation at A. is found to subtend an angle of 3′, bearing right down upon the fort or battery in the direction A. B. and having run by the log 5348 yards, or a little more than a league to place B. another observation is taken, and the angle subtended by the flag-staff, at this place, is found to be 9′.—From these *data* the distance from the fort or battery, as well as the height of the flag-staff, may be found by the foregoing rules, if the angles have been *truly* taken, and the distance between each place of observation as *truly* ascertained; to guard, however,

ever, against any error arising from the irregular motion of the ship, in not properly *defining* the object, or by not getting the *true* distant run by the log, between the places of observation A. and B.—the ship is kept in her course till she arrives at C. where another angle of the flag-staff is taken, of 40′ the last distance run being given by the log 2072 yards: From these *data* then the several distances of the ship, at A. B. and C. from the battery or fort, may be *truly* found; and also the height of the flag-staff.—The height of the flag-staff, coming out the same from all the places of observation, A. B. and C. prove, to demonstration, the several *distances* run, the *angles* taken, and respective *distances* from the SHIP, at A. B. and C. to be all *true*.

To prove the distance and height of the flag-staff by the common numerical or simple rule:—The logarithmic, &c. having been sufficiently explained, need not be repeated.

To

To find first the *distance* of the SHIP, from the *fort or battery* at the several places of observation, and from *thence* the height of the *flag-staff*. —Let 5384 yards, the distance between the first and second place of observation, or between A. and B. be multiplied by 9′, the angle subtended by the *flag-staff* at B. and this product be divided by 6′, the difference between the two angles A. and B. the quotient will be 8022 yards, the *distance* of the *fort or battery* from the SHIP at A. the *first* place of observation; and if the *distance* between A. and B. 5384 yards, be substracted from the whole distance, A. F. 8022 yards, the remainder 2674 yards, will be the *distance* from B. the place of the SHIP, where the *second* observation was taken, to the *fort* or *battery*, or rather to the *flag-staff* erected thereon: also, if the *distance* between the second and third places of observation, or between B. and C. or 2072 yards, be multiplied by 40′, the angle subtended by the *flag-staff* at the *then* place of observation C. and the

the product be divided by the difference of the *two* angles at B. and C. 40′—9′=31′, the quotient will be as above 2674, the *distance* from B. to F. or from the *second* place of observation to the *fort or battery*: and the *distance* between B. and C. 2072 yards, or between the *second* and *third* places of observation, substracted from the *distance* between B. and the *fort* 2674 yards, will give the *distance* 602 yards, from C. the *third* or *last* place of observation from the *flag-staff* on the *fort or battery*. The several distances then will be from A. to D. E. F. the *flag-staff* on the *fort or battery*, 8022 yards; from B. 2674 yards; and from C. 602 yards.

From the above *data* to find the *height* of the *flag-staff* D. E. F. and from *thence* to prove the foregoing observations of *angles* and *distances* to have been *truly* taken ;—

Take

Take out from the Table of *Horizontal Diſtances* the tabular number for 3′, the *firſt* ſubtended *angle* of the *flag-ſtaff* from the place of the ſhip at A. 1146; if the *diſtance* between A. and the *fort*, 8022 yards, be divided by the above tabular number, the quotient will be 7, the *height* of the *flag-ſtaff*, in parts of the ſame meaſure, the *diſtances* are found in, *viz.* yards.

Again:—The diſtance between ſtation the *ſecond*, or the place of obſervation at B. and the *fort*, 2674 yards, divided by the *tabular number* for the angle, at *this* ſtation, 9′, *viz.* 382, will give 7 for the quotient, the height of the *flag-ſtaff* in yards, as before.

The *laſt* diſtance or place of obſervation, or from C. to the *fort*, 602 yards, divided by the *tabular number* for 40′, *viz.* 86,—gives a like quotient of 7 yards, as in the *two* foregoing operations.

 Thus

Thus do all the various *angles*, *distances*, and *heights*, prove each other, from *each* and *every* respective place of observation.

To bring the whole into *one* point of view in simple numbers—

The Tabular Numbers to the Angles are,

Angle.		Tab. Num.
A	3′	1146.
B	9′	382.
C	40′	86.

The several *distances* to the *Fort* or *Battery* from the places of observation, A. B. C. are as follow :—

A. B. or $\dfrac{\overset{\text{Yds.}}{5348} \times 9'}{9-6}$ = 8022 Yds., or distance from A. to F.

B. C. or $\dfrac{2072 \times 40}{40-9}$ = 2674, or distance from B. to F.

B. F. or 2674—B. C. or 2072 = 602, or dist. from C. to F.

Proof

Proof of the *Flag-ſtaff's* height.

		Yds.		Yds.		Yds.
Dist.	A. F.	8022	B. F.	2674	C. F.	602
		——— = 7;		——— = 7;		——— = 7. Yds
Tab. Num.	3′	1146	9′	382	40′	86

Q. E. D.

Thus it appears clearly demonſtrated above, that it is of no conſequence what the *diſtance* is between ſtation and ſtation, ſo that the diſtances are *true* where more than *one* is taken, *i. e.* where *diſtance* and *extenſion* of the ſame object are required, both of them being *unknown*.

Hence, then, the value of the Patent Teleſcopical Micrometer, as a *nautical inſtrument*, for aſcertaining diſtances and extenſion of objects at SEA, as well as on ſhore, and with *nearly* the ſame accuracy, if due care be taken, either by a *ſingle* obſervation, from known *extenſion*, or by *two* or *three*, as circumſtances occur, and when greater truth and accuracy are required, from unknown diſtance and extenſion,

To

To our *brave* TARS, who never want to know the *diſtance* or *ſize* of the ENEMY's SHIP till they are near enough to board it, the Patent Teleſcope, in this reſpect, it will be allowed, can be but of *little uſe*; and, it is ſuppoſed, *this* was the reaſon why a *Noble* and *Gallant* ADMIRAL * would not even hear the *name* of the Patent Teleſcope, or any other inſtrument for meaſuring the *diſtance*, &c. of an ENEMY, mentioned than a TWO-AND-FORTY POUNDER; which, experience had taught HIM, gives, at one and the ſame moment, *their* DISTANCE and DURATION!!! But when the *Noble Lord* ſhall have been *well* aſſured of its uſefulneſs in *other* reſpects, in *eclipſes*, in *tranſits*, in *occultations*, in *lunar obſervations*, &c. he will doubtleſs form a more favourable opinion of it, as an inſtrument capable of anſwering many *valuable* NAUTICAL purpoſes, and indeed ſuch as cannot well be diſpenſed with.

IT

* Duncan.

IT is true, that the *more* perpendicular the object, whose *distance* or *height* is required, is to the axis of the Telescope, the *more* exact will the result be; that an object upon any very considerable eminence, whose *distance* and *extension* is required, cannot be so *truly* taken by the foregoing rules, as if it were upon a *true* horizontal level; unless, as before observed, it be perpendicular to the axis of the Telescope: that a man placed at the top of St. Paul's, would subtend a much *less* angle from the iron railing at the bottom, than at *twice* the horizontal distance of its height:—or if the same man be placed on the summit of a high mountain, he will subtend a much less angle, (if perpendicular to the horizon, and oblique to the axis of the Telescope) than if viewed from the foot of the mountain, on the plain below, at *twice* the horizontal distance, where the mountain itself subtends a very considerable angle, at its base: but even here, the height of a man bears so inconsiderable a proportion to the altitude of a mountain, that, in *military* operations,

operations, it is of no consequence; neither is it in *nautical*, in measuring the distance between two ships, between a ship and an island, cape, harbour, fort, &c.—In trigonometrical, &c. surveys, it will be proper to make an allowance for the diminishing angle of objects, in proportion to their elevation, above the plain of the *horizon*, where objects are not viewed perpendicular to the axis of the Telescope, as before observed:—*And it is intended, some time hence, to adapt the Patent Telescopical-Micrometer to the purposes of surveying, when a suitable table of allowances for ALL* elevations *and* depressions, *to reduce hypothenusal to base lines, will accompany the instrument, fitted to a Theodolite.* The following table may, however, suffice for present *general* purposes, to shew what proportion, in distance, should be deducted to bring the hypothenusal to a base-line, from *four* degrees of elevation or depression, to *thirty-six*; beyond which it would be found useless to carry it either for *military* or *naval* purposes, it being near enough the truth, and sufficiently

extensive

extenſive for both; to allow for the *range* of a gun, or to find the *diſtance* of an iſland, &c. &c.

Table of Allowances to reduce Hypothenuſal to Horizontal Diſtances.

Deg.	Diſt.	Deg.	Diſt.
4°	$\frac{1}{400}$	20°	$\frac{1}{15}$
5	$\frac{1}{200}$	22	$\frac{1}{14}$
6	$\frac{1}{130}$	24	$\frac{1}{11}$
8	$\frac{1}{100}$	25	$\frac{1}{10}$
10	$\frac{1}{50}$	26	$\frac{1}{9}$
12	$\frac{1}{40}$	28	$\frac{1}{8}$
14	$\frac{1}{30}$	30	$\frac{1}{7}$
16	$\frac{1}{25}$	32	$\frac{1}{6}$
18	$\frac{1}{20}$	36	$\frac{1}{5}$

Suppoſe it be required to find the *horizontal diſtance* to a wind-mill, ſtanding upon a hill, whoſe angle of elevation is known to be 12 degrees,—having found the hypothenuſal or direct diſtance to the mill, by the foregoing rules, to be 1440 yards—againſt 12 deg. in the Table ſtands $\frac{1}{40}$ in the column marked Diſt. which ſhews, that *one fortieth* of the hypothenuſal diſtance is to be deducted to find the *true*

horizontal

horizontal diſtance; thus, $\frac{1}{40}$ = 36 yards, is to be taken from 1440, which leaves the *true* horizontal diſtance 1404 yards.

Again;—Standing upon a hill, whoſe angle of depreſſion to a houſe, in a meadow below, is 22° degrees, and whoſe hypothenuſal diſtance is 2730 yards; required the *true* horizontal diſtance.—Againſt 22 deg. in the Table ſtands $\frac{1}{14}$, which ſhews, that *one fourteenth* of the diſtance is to be deducted from the hypothenuſal or direct diſtance, to give the *true* horizontal diſtance— $\frac{1}{14}$ = 195, which ſubtracted from 2730, the *hypothenuſal* or *direct diſtance*, in yards, or other meaſure, leaves 2535, the *horizonal diſtance* required.

The following Table of Multipliers and Diviſors for *all* general diſtances, from twelve inches to a league, will be found uſeful to expedite any calculation required in Engliſh meaſure.

Table

Table of Multipliers or Divisors for finding Distances and Extensions.

Inches. 12	Feet. 1	Yard						
36	3	1	Toise					
72	6	2	1	Rod				
198	16½	5½		1	chain			
792	66	22	11	4	1	Furl.		
7920	660	220	110	40	10	1	Mile	
63360	5280	1760	880	320	80	8	1	Leag.
190086	15840	5280	2640	960	240	24	3	1

Note.	60‴ or Thirds, make 1″ or Seconds. 60″ or Seconds, make 1′ Prime or Minute. 60′ Primes or Minutes, 1° or Degree Equal to 69½ British Miles.

Having fully explained the *usefulness* and value of the *Micrometrical* part of the instrument as adapted to the *Telescope*, for *military*, for *naval*, and for all the general purposes of *Longemetry* and *Altimetry*, within its field or power; it remains to be shewn, in what way the in-

ſtrument is uſeful and to be applied in *Microſcopical* Obſervations.

As a Microſcope it is capable of meaſuring the *lineal* and *comparative* dimenſions of very ſmall objects; and, in proportion to its magnifying power, is rather a thing of amuſement than of any great uſe, except that it be to find the magnifying power of other Teleſcopes, which is done by meaſuring the diameter of the pencil of light at the eye of the Teleſcope, whoſe value is required; and when this pencil of light is well defined, it will ſhew the comparative value of the magnifying power of different Teleſcopes, as ſhewn by the Micrometer Diviſions on the Scale.

The method of ſhewing the comparative value is this: Take the *firſt* and *ſecond* tube, or that which goes by the name of the *eye-tube*, and the next to it, and apply the aperture of the ſecond tube to the eye-end of the Teleſcope, whoſe comparative value is required, till

till by ſliding the firſt tube backward and forward, as in bringing it to a focus for viewing objects, you clearly define the round pencil of light of the Teleſcope under examination, when the Scale of the Micrometer will point out its value. Thus may the comparative value of any number of Teleſcopes be found.

To uſe the inſtrument as a Microſcope for examining ſmall objects, and meaſuring their *lineal* extenſion or dimenſions, let the *eye-tube* be unſcrewed from the other parts; then by placing any ſmall inſect, or object of any kind, on a piece of white paper, and looking through the tube, moving it up or down, if held in a vertical poſition, or backward and forward, if horizontal, till the object be well defined*; the Micrometer Scale will then point out its lineal dimenſions in hundredths or thouſandths of an inch, by means of the Vernier or Nonius.

EXAMPLE

* Whether the inſtrument be uſed as a Teleſcope or Microſcope, always ſlide the tube to the proper focus.

EXAMPLE 1.—Let it be required to find the *diameter* of hair.

Place the hair, as before directed, on a piece of white paper, and bring the central hairs or wires in one, as at *a*. Fig. 1. let the *hair* in question, whose diameter is required, be viewed through the eye-tube of the Telescope, brought to its proper focus; then by moving the nut or screw A. the central parallel hairs or wires will open and measure the diameter of the hair under examination, when the *Micrometer Scale* will shew its dimensions, to the thousandth part of an inch, if carefully observed.

EXAMPLE 2.—Placing a small insect under the tube, as before, suppose a small fly of any sort, whose *lineal* extension may be required, lay it at right angles to the hairs or wires of the Micrometer, thus +, then by turning the nut or screw A. as before, the central hairs or wires subtending the length of the fly, the Scale

Scale will give its meaſure, as in the former Example.

These Examples, and the method of examining ſmall objects, are ſo very ſimple, that a repetition muſt be needleſs :—in this way may the whole body or limbs of an inſect, or ſmall object of any kind, be meaſured, where the *lineal extenſion* or comparative ſize is required.

IF the preceding pages have been read with the leaſt tolerable degree of attention, it is impoſſible but the mereſt novice in the ſcience of common numbers muſt be well acquainted with the method of performing all the examples illuſtrative of the *principles*, and various *uſes* of the *Patent Teleſcope.*

It was never intended to go further into explanation than what would be juſt ſufficient for practical uſe ; and it is hoped enough has been

ſaid,

said, and examples enough shewn, at large, to render every thing familiar and easy to perform.—Nothing further then seems necessary to be said than to advise and recommend to those who may *use* the *Patent Telescope*, either for finding the *distance* or *extension* of objects, or in any other respect to be *careful* in their observations.—To keep the instrument *firm* and *steady*.—To define the object under examination, very *nicely*, between the parallel hairs or wires.—To read off the subtended angle measured by the divisions of the Micrometer *truly*, together with the value of the Vernier or Nonius, (always DOUBLING the same for the *full* value of the angle.)—And to take out the tabular number, corresponding with the subtending angle, right. If then, the *last* part of the operation be *truly* performed by *multiplying* or *dividing* the tabular number, as before taught, the result will be, the *true* distance, extension, &c. of the object in any measure required.

FINIS.

ADDENDA.

After the preceding pages had been printed, the following Problem, suggested by an officer of rank in the service, was sent to the Author, saying, "It may sometimes be of great consequence, in *military* operations, to be acquainted with the difference in elevation of particular objects," which the small, and very general, table of allowances (p. 65) was never intended to give without calculating the perpendicular from well known *data*, (47th Eucl.) by extracting the square root of the difference of the base and hypothenuse.

 It

It was mentioned in page 64, that the Patent Telescope would sometime hence be adapted to the business of *surveying*, when a suitable table would accompany such instrument, which would fully answer the purpose of solving *all* the properties of a triangle, right or oblique, being, in its present form, calculated to ascertain *point blank* distances, and the size or extension of objects only, and not their difference of level or bearings from each other. The bearings and angles of elevation or depression, if required, must therefore be found by a quadrant, or other instrument; then will the additonal *new* epitomized table, (p. vi,) by simple multiplication or division, solve the problem, fig. 1. pl. 2. proposed, and all similar ones; and will be a *datum* for the more readily solving those of an oblique kind also.

PROBLEM

PROBLEM PROPOSED.

"To reduce hypothenusal to horizontal distances, and to ascertain the difference in height of two places.

"Let A and C, (fig. 1. pl. 2.) be the two places, A, being the place of observation; A, C, the hypothenusal distance (suppose 150 yards) taken by the telescopical micrometer; *d*, *e*, the depression, taken by a theodolite (or quadrant) suppose 16°.

To solve the above.

"Search in the nautical tables, traverse table, Hamilton Moore's Epitome, tab. III. (or any other,) for the table shewing the difference of latitude and departure for 16°, that is to say, the table shewing the value of all the sides of the rectangular-triangle, of which *one* acute angle A,

 and

and *one* side, A, C, are known; and then 150, hypothenusal distance, gives for A, B, 144.$\frac{2}{10}$ horizontal distance; and 41.$\frac{3}{10}$ for B, C, difference of height."

It having been observed, that the table, p. 65, calculated on very general principles to find the horizontal distance of objects *only*, and not their *perpendicular* height, could *not* solve the above problem; as far, however, as it is adapted, it will give *nearly* the same result as the above, or any other nautical tables; for, if the allowance, in table, p. 65, opposite to 16°$=\frac{1}{25}$, be deducted, as before taught, it will give 144 yards for the horizontal distance A, B, of the problem, differing only two tenths of a yard rom the nautical tables:—but this will not *always* come out so near the truth. The following table, however, calculated on the nautical principles, and epitomised, to get rid of a cumbrous mass of figures, which may be dispensed with in military practice, will give the same, or

nearly

nearly the ſame, reſult, at all elevations and depreſſions, and be a *datum* for finding the diſtance B, C, fig. 3. pl. 2. or any ſimilar diſtance.

To illuſtrate this by a few examples:

EXAMPLE I.

Let the *above* problem be taken where the hypothenuſe, or diſtance A, C, fig. 1. p. 2. equals 150 yards, and the angle of depreſſion, *d, e*, equals 16°, are given to find the baſe, or horizontal ſide, A, B, and the perpendicular B, C.

Rule to find the horizontal diſtance A, B:— Multiply the hypothenuſe by the tabular number, in the ſecond column, oppoſite the given angle, marked at the head of the table Hor.

Thus, if the hypothenuſe, or diſtance, A, C, =150, be multiplied by .961, the tabular number for 16°, it will give 144. and leave a decimal

FOR MILITARY, &c. PRACTICE.

NEW TABLE

FOR COMPUTING THE HORIZONTAL SIDE OR BASE, AND PERPENDICULAR OF A RECTANGULAR TRIANGLE; THE HYPOTHENUSE AND ONE ACUTE ANGLE BEING KNOWN.

Deg	Hor.	Per.	Deg	Hor.	Per.	Deg	Hor.	Per.	Deg	Hor.	Per.
1	1.	57.2	23	.92	2.36	45	.707	1.	67	.391	.424
2	.999	28.8	24	.913	2.24	46	.694	.966	68	.374	.404
3	.998	18.9	25	.906	2.14	47	.682	.933	69	.358	.383
4	.997	14.24	26	.898	2.05	48	.669	.9	70	.342	.364
5	.996	11.4	27	.891	1.96	49	.656	.869	71	.325	.339
6	.994	9.5	28	.882	1.88	50	.642	.839	72	.309	.325
7	.992	8.13	29	.875	1.80	51	.629	.809	73	.292	.305
8	.990	7.1	30	.866	1.73	52	.615	.781	74	.276	.287
9	.988	6.3	31	.857	1.66	53	.602	.758	75	.259	.268
10	.984	5.65	32	.848	1.6	54	.588	.726	76	.242	.249
11	.982	5.15	33	.839	1.54	55	.573	.7	77	.225	.231
12	.978	4.7	34	.829	1.48	56	.559	.674	78	.208	.212
13	.974	4.33	35	.819	1.42	57	.544	.649	79	.191	.194
14	.970	4.	36	.808	1.37	58	.530	.625	80	.174	.1766
15	.966	3.73	37	.799	1.32	59	.515	.601	81	.156	.1579
16	.961	3.49	38	.788	1.28	60	.5	.577	82	.139	.1404
17	.956	3.27	39	.777	1.235	61	.485	.554	83	.122	.1228
18	.951	3.08	40	.766	1.19	62	.469	.531	84	.104	.1052
19	.945	2.9	41	.755	1.15	63	.454	.509	85	.087	.0874
20	.940	2.74	42	.743	1.11	64	.438	.487	86	.069	.0698
21	.933	2.6	43	.731	1.071	65	.423	.467	87	.052	.0520
22	.927	2.47	44	.719	1.034	66	.407	.445	88	.035	.0350
									89	.018	.0180

mal remainder of .15 instead of .2, approximating near enough the truth for any *military* operation.—For *nautical* purposes, the nautical tables are always at hand on board ship, and may be used, if preferred.

Rule to find the perpendicular B, C:—Divide the horizontal distance, above found, by the tabular number, in the third column, marked Per. opposite the given angle, and the quotient will come out 41.3, the perpendicular B, C, required, in any measure of the hypothenuse given.

EXAMPLE II.

Required the distance between two forts, or two ships, B, C, fig. 2. pl. 2. their distance from A, the place of observation, being equal, suppose 1250 yards, and the bearing from each other 34°.—Here, the angle being isosceles, form it into two right angled-triangles, A, D, B, and A, D, C;—*b*, *c*, and *c*, *d*, will then be equal to 17°.

Multiply

Multiply the tabular number opposite 17° .956 into the diſtance A, B; cutting off the decimal figures, leaves 1195, the horizontal diſtance A, D; this, divided by its proper tabular number 3.27, gives 365.4 for B, D, or C, D, which, being added together, gives the diſtance from fort to fort, or from ſhip to ſhip, 730.8 yards required.

EXAMPLE III.

In the ſcalenous, or oblique-angled triangle, A, B, C, fig. 3, pl. 2, the diſtance A, B, 1050, and A, C, 1432 being found, by the teleſcope, as before, required the diſtance from B to C.

It will naturally ſuggeſt itſelf that this is one of the moſt uſeful problems in this branch of military or naval tactics; and, although the epitomiſed table will not give the diſtance B, C, ſo readily as the perpendicular B, D, is found, it will furniſh *data* to ſolve the problem as truly;

truly; and, probably, as ſoon, as the nautical tables, to perſons unaccuſtomed to ſearch in ſuch tables.

Taking A, B, 1050 yards, as hypotheniuſe to the aſſumed baſe, A, D, in the line, A, C, and multiply, as before, the tabular number correſponding to the ſubtended angle, *f*, *g*, 12°, which will be found in its proper column, .978, the produce, 1027, will equal A, D, which divided by the tabular number in the next column for perpendicular, 4.7 will give B, D, equal 218.—Taking A, D, from A, C, leaves 405 equal, D, C; having then B, D, = 218 and D, C, = 405, the diſtance from B to C, 460, is found by extracting the ſquare root from the ſum of the ſquares of B, D, and D, C; or in any nautical traverſe table

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In the mechanical conſtruction of any inſtrument, mathematically true in principal, much depends upon the nature of the materials with

which it is formed, and much on the ſkill and ingenuity of the artiſt. It is, therefore, next to an impoſſibility that every inſtrument, even from the hands of the ſame artiſt, ſhould be found *exactly* alike, though all will give the ſame reſult, when practically applied, if due attention be paid to the foregoing, and following directions; which it was thought proper to mention, in the Addenda, where *great* accuracy is required in aſcertaining diſtances.

It was mentioned, page 15, that the *whole* diviſions, on the ſcale of the micrometer, were minutes of a great circle; this, as above obſerved, is mathematically true; but the difference between a mathematical and a phyſical line, neceſſarily renders the diviſions of the micrometer ſcale liable to a ſmall error, proportioned to the manner in which they are executed;—the different refracting powers of the lenſes, and the ſtrength of the lines, forming the diviſions of the micrometer ſcale, will alſo cauſe a variation of

of a few seconds in the value of *some* of the telescopes:—The mean value, therefore, of each single division, will be engraved on the tube of every one, to be properly allowed for.

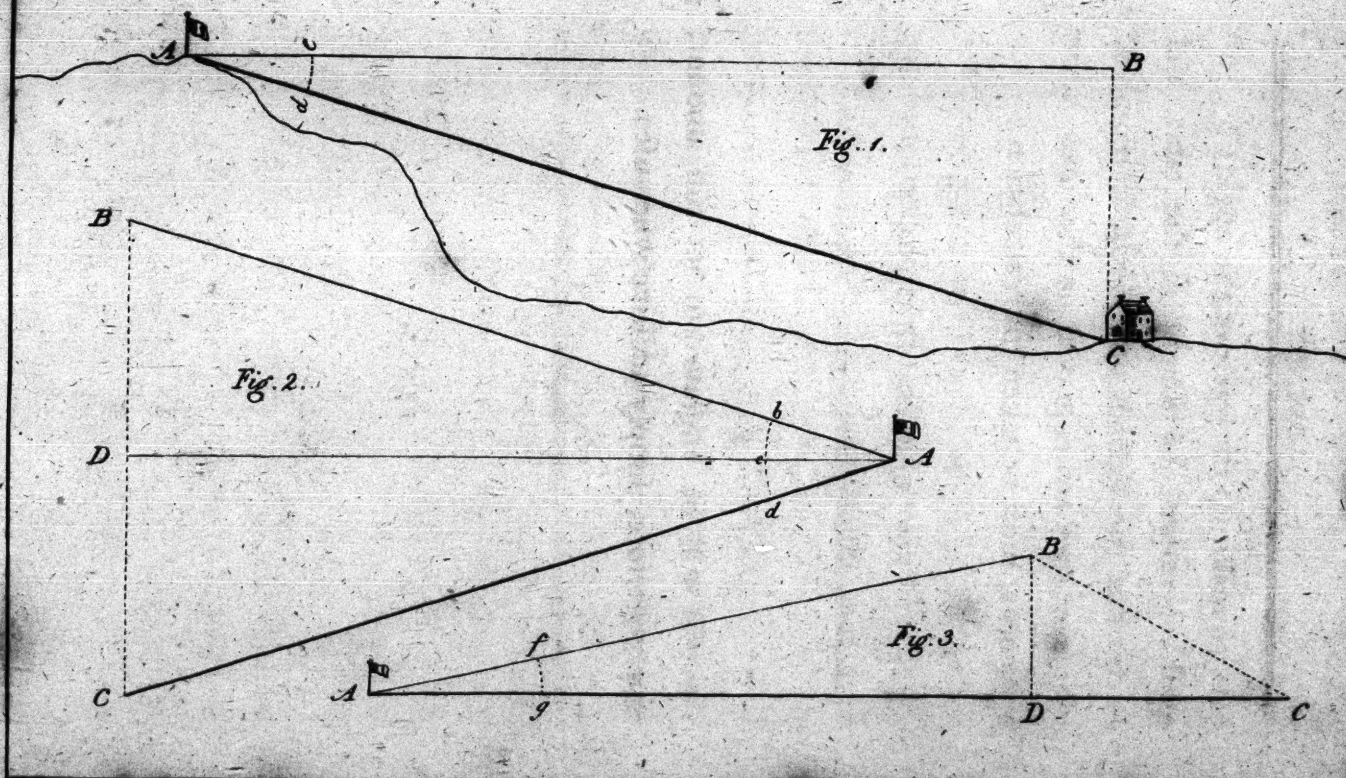
Where great accuracy is required in ascertaining a distance, the size, or extension, of an object, or the difference in point of elevation of *two* objects, a single second is of some consequence, and it will be proper to add to the division, or divisions, which any object is found to subtend, the mean value of the seconds (and even *thirds* in astronomical observations) due to each division, the loss in value, occasioned by the difference before mentioned, between a mathematical and a physical line. Suppose the mean of each division should be found equal to 1′ 2″, or other number of seconds, and that an object subtends 3 divisions, which, *doubled* as directed, gives 6′; instead, therefore, of entering the table of horizontal distances with 6′, to find the distance, the 2″ must be added to every *single* divi-

ſion, to make up the value of the angle; 6′. 12″ muſt, therefore, be ſought in the table, and in *this* way the ſeconds and *thirds*, if required, wherever they are engraved on the tubes of the teleſcopes, muſt be taken into calculation.

The vernier muſt be thus proportioned for very nice obſervations.

The fixed value will require no ſuch correction; it will be engraved to its full amount, and, therefore, ſimply additive when uſed.

FINIS.


A
B
C
c
d
Fig. 1.
B
D
C
A
b
c
d
Fig. 2.
A
B
C
D
f
g
Fig. 3.

ERRATA.

Page 17, fifth line from the bottom, for *issoscles*, read *isosceles*
—— 65, third line of table, for $\frac{1}{130}$ read $\frac{1}{150}$
—— 67, third line from the bottom, for *longemetry* read *longimetry*